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## “Quantum origins of ontic emergence”

For the past half century, substantial progress has been achieved in exploring various modes of multi-level emergence in nonlinear dynamical systems (Kauffman, 1993). However, such emergence has typically been viewed as merely epistemic and, via supervenience concepts, mostly reducible to physics substructure—substantive models for genuine novelty at higher levels, or ontic emergence, have remained elusive. Recently, research deploying a combination of category-sheaf theoretic tools, the decoherence approach to quantum physics interpretation, and philosophic analyses of *potentia* has enabled a new route to understanding ontic emergence. Rules of transition emerge from the local to the global and conversely such that global event structures are consistently maintained and augmented; concurrently variable local Boolean frames [providing simple yes-no logic with the principle of the excluded middle] contextualize the actualization of events, and “each new actualized event creates a novelly integrated whole.” (Epperson and Zafiris, 2013, 344). Overall, this quantum-based scheme encompasses the inclusion of several seemingly incompatible dualities (input-output, local-global, quantized-continuous, actual-potential, among others), which are found to be mutually implicative at a deeper level. Our analysis reveals that it is impossible to conceptualize one principle within such dipolar pairs in abstraction from its counterpart principle. Such category theoretic analysis provides a rigorous mathematical means for “relating relations,” for explicating the role of potential relations and context in quantum processes, and for the localization of quantum observables with respect to local Boolean contexts. Indeed, for any quantum system, and thus for any physical system, such context specification is essential because the only closed system, if that, is the universe at large. Consequently, full analysis of any physical system necessarily goes beyond the dyadic relation of input-output to the triadic relation of input-output-context. Philosopher James Bradley has stated that three of the most fundamental questions of ontology are that of (1) origin, (2) difference, and (3) order. Pre-given facts and *potentia* provide the ‘origin’ (Peircean firsts), basic quantum processes of input-output yield the ‘difference’ (Peircean seconds), and such process, with its actualization of *potentia*, inevitably requires (at whatever scale) local Boolean context, thus the Peircean triad, input-output- context, and resultant ‘order’. The methodological goals of reduction and context independence can often represent good approximations, but inevitably just that—never strict entailment. At multi-scale, physical constraints and relationships, all emergent from fundamental quantum process, enable high levels of determination, yet there is inevitably a context, some delimitation of possible constraints, and real (non-Boolean, pre-space?) *potentia* that are part of ongoing processes, at whatever level/scale, the actualization of events —“one darn thing after another.” Semiotic relations involving an ‘interpretant’ may be limited to biosemiotics, but triadic relations are fundamental to quantum process, and thus to all natural systems.

### References

Stuart A. Kauffman, *From Origins to Order: Self-Organization and Selection in Evolution*, Oxford University Press, 1993.

Michael Epperson and Elias Zafiris, *Foundations of Relational Realism: A Topological Approach to Quantum Mechanics and the Philosophy of Nature*, Lexington Books, 2015.